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Forthcoming Events.

JUNE 4 to 6.

Institute of British Foundrymen. — Annual Convention at Newcastle.

JUNE 19 to 28.

International Foundry Trades Exhibition.—At Bingley Hall, Birmingham.

JUNE 25 to 27.

Foundry Technical Congress.—Bingley Hall, Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

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Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

The Foundry Exhibition.

The devotion of a maximum amount of thought to essentials and a minimum to non-essentials is a characteristic which often distinguishes the successful from the unsuccessful foundry manager. Worrying over trifles, which are truly trifles, is approaching sheer waste of time, whilst the clear visualisation of the *toute ensemble* of the department and its requirements is of prime importance. Associated with this is a striving to increase output; to secure the best possible return on money invested; to instal the most economical plant to maintain; to improve the quality of the product, to utilise the most suitable materials, and to be so familiar with modern plant that the result of its installation can be approximately foretold. If foundrymen visiting the International Foundry Trades Exhibition, which opens on Thursday, June 19, at Bingley Hall, Birmingham, will bear these essentials in mind, then the exhibitors will be well satisfied. Our unique knowledge of foundry conditions in Great Britain enables us definitely to state that no foundry is so well organised and equipped that there is not room for improvement. Further, it is impossible to imagine a more simple yet adequate means of making one's self *au courant* than by visiting a representative foundry equipment and supply exhibition. Having dealt with the basic principle of successful foundry management in relation to foundry exhibitions, it would seem but waste of words to reiterate the smaller aspects of the case, such as the central geographical situation, the convenience of the period of opening, the social aspect and that useful gossip as to the progress of methods and materials, to which a certain amount of importance can be attached. Of real importance, however, is the foundry congress, which is to be held from June 25 to 27, at which a number of important Papers are to be read by very prominent British and foreign foundrymen. Of outstanding importance is the Paper by Dr. Werner, the President of the German Foundrymen's Association, who will deal with recent technical developments in German foundry practice. This should constitute a unique opportunity of learning first hand whether the developments in Central Europe, which has been divorced for a decade from Western Europe, are of a similar character. German foundry thought has been much occupied; foundry sands, refractories, cupola practice, long life moulds, desulphurisation of metal by soda ash, Drefenthaler's method of producing an all-graphite-pearlite structure in cast iron, the hardness of sand moulds. It is up to British foundrymen to make themselves familiar with the practical results, such as one has a right to expect from the president of a foreign technical foundry association. The discussion on his address will afford such an opportunity.

By way of a reminder, we would draw attention to the fact that the proposed Home Office Regulations for the Cleaning of Castings are still under consideration, and the Birmingham Exhibition will afford opportunities for examining some of the latest plant. Every manager should be in a position to tell his directorate the present position of his foundry in this respect, the amount of expenditure to be incurred for the complete and partial requirements of the proposed regulations, the subsequent effect on output, the cost of temporary, if any, dislocation, and the cost of upkeep. The Foundry Exhibition assumes increased importance on this account, and it is imperative that every foundry in Great Britain should be adequately represented.

Foundry Queries.

Centrifugally Cast Bearings.

Some time ago we were experimenting with the production of various bushes we required, both in phosphor bronze, gun metal, and lead alloy, by centrifugal process, but unfortunately we were not successful, due to the segregation of the various metals, but seeing that we have a large quantity of these bushes to make which are on an average, say, about 3-in. bore, walls ⅜ in. thick, and about 6 in. long, with a flange at one end only, we still think there should be better methods of producing them than with the ordinary sand moulds and cores.

We have been noticing of late that considerable progress has been made with the production of cast-iron parts in metal moulds, and we are very anxious, if possible, to produce these bushes with metal moulds, and, if possible at all, with a metal core.

It is possible that this may have to be of a collapsible type, but being a member of the Association I am writing to see whether you could possibly give me any advice in the matter. Are there any books which would throw any light on the subject? If not, do you happen to know any other member of the Association to whom I could write who you think would assist in any way?

If we can produce these with metal moulds and cores we can cut down our machining allowances to a minimum, and it will cheapen our production. Any assistance you can give me on this matter would be very much appreciated.—G. R. W.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Silicon in Centrifugal Castings.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I should like to call attention to a point which occurs in the Paper entitled "Cast Iron in Motor Car Construction," by Mr. F. H. Hurren, published in your issue of May 22, 1924, relating to the silicon content in piston ring castings cast by the centrifugal process. Mr. Hurren states that in centrifugal castings the silicon content is high, and generally in the neighbourhood of 4 per cent.

In the piston-ring drums which are being produced by the firm with which the writer is connected, the average silicon content is now, and has been for some considerable time, 2.75 per cent. We are gradually reducing even this figure, and there is no reason why we should not ultimately produce castings by our centrifugal process with the same silicon content as sand castings.—Yours, etc.,

CENTRIFUGAL CASTINGS, LIMITED.
J. E. HURST,
Managing Director.

Kirkstyle Road, Kilmarnock.
May 27, 1924.

Catalogues Received.

Foundry Metallurgical Service.—Messrs. Beecroft & Partners, St. Peter's Close, Sheffield, are circularising the foundry trades with a four-page leaflet descriptive of their laboratories and services they give, which includes chemical and micrographical analyses and mechanical testing.

Scrap and Plate Shears.—We have received from Mr. Henry Pels, of 40, Great Marlborough Street, London, W.1, a catalogue outlining plant for the rendering of scrap into suitable form for remelting. Now that so much scrap is being used in iron foundry practice, the matter of cutting up plates and sections becomes of increasing importance, and ironfounders should make themselves familiar with this type of plant.

Steel Pressings, etc.—We have received from Messrs. Joseph Sankey & Sons, Limited, a comprehensive catalogue conveniently divided into six sections. Section 4 is of direct interest for the foundry trades, as it outlines the ranges and types of pressed steel seamless foundry ladles which the company stock. Pressed steel barrow bodies is another foundry speciality dealt with. Section 6 is of universal engineering interest, as it covers fairly completely the field of steel office and storeroom furniture. The single locker illustrated appears to us to be ideal for installing in foundries as wardrobes for the workers' clothes, as is almost invariably practised on the Continent.

Publications Received.

A Handbook for Oxy-Acetylene Welders, by Leonard M. Fox.

Mr. Fox is the general manager of Messrs. Allen-Liversidge, Limited, who are well known to the foundry trades as suppliers of dissolved acetylene.

The object of this book is to provide a work of reference to provide instruction for those engaged in oxy-acetylene welding either practically or supervisory. Generally speaking, the author has succeeded, and we have no hesitation in recommending foundrymen to secure a copy, which we understand will be sent gratis to *bona-fide* applicants. It is in the editing of the work, especially the section dealing with cast iron, where some carelessness has been exhibited. For instance, we are told on page 34 that "it (sulphur) should never be present in quantities of more than 1.0 per cent." We presume 0.1 is meant. Again, on page 35, "when cast iron is in fusion, it oxidises very rapidly. The oxide begins to form at a bright-red heat (843 deg. C. according to another section of the book) and melts at a temperature of 2,400 deg. C. to 2,450 deg. C. The metal itself melts at a temperature of 300 to 400 deg. C. below this." Here we presume that the Fahrenheit scale is meant.

Personal.

MR. GEORGE STRACHAN, who has returned from the United States, has been re-elected to the board of the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow.

MR. T. B. HUNTER, locomotive carriage and wagon superintendent of the Wirral Railway, of the L.M. & S. Railway, has been appointed district locomotive superintendent, Brecon.

MR. F. CLEMENTS, general manager of the Park Gate Iron and Steel Company, Limited, has been the recipient of a handsome presentation from the officials and men, in celebration of his marriage.

MR. A. K. WILSON, managing director of Spear & Jackson, Limited, Ætna Works, Sheffield, has lately returned from a business tour of Australia, New Zealand, South Africa, and Canada, which occupied eleven months.

Wills.

HALEY, N., formerly chairman of E. & W. H. Haley, Limited, ironfounders ...	£5,010
MARSHALL, P. J., of Knaith Hall, Gainsborough, Lincs, lately a director of Marshall, Sons & Company, Limited, Britannia Foundry, Gainsborough	£44,413
FISHER, H., of Tapton Mount, Manchester Road, Sheffield, Yorks, founder of Harry Fisher & Company, steel and file manufacturers, Kingfisher Works, Sheffield	£33,160
HUNTER, R., of Kirkmailing, Larbert, Stirlingshire, ironfounder, lately managing director of Walker, Hunter & Company, Limited, a former chairman of the Falkirk and District Ironfounders' Association	£46,295

For London Foundrymen.

Mr. E. H. Brown, of 91, Devonshire Road, Forest Hill, London, S.E.23, proposes organising a party for visiting the International Foundry Trades Exhibition, doing the journey by motor coach. Intending visitors should write Mr. Brown at the earliest moment.

The Foundry of the Sunbeam Motor Car Company.

The Sunbeam motor car bears one of the oldest names in the motor industry, the first vehicle having been made as long ago as 1899. Ever since then the efforts of the Company (which adopted its present title in 1904) have been concentrated on quality rather than quantity. Thus in any description of the Sunbeam Foundries this factor of quality must be recognised and appreciated. The foundry has been in operation for many years, and the personnel have an unusually wide experience in foundry practice as applied to automobile castings. The works are situated in Wolverhampton, some distance from a railway siding. There is ample space for extensions. An excellent welfare department is run in connection with the works, and is much appreciated by the employés.

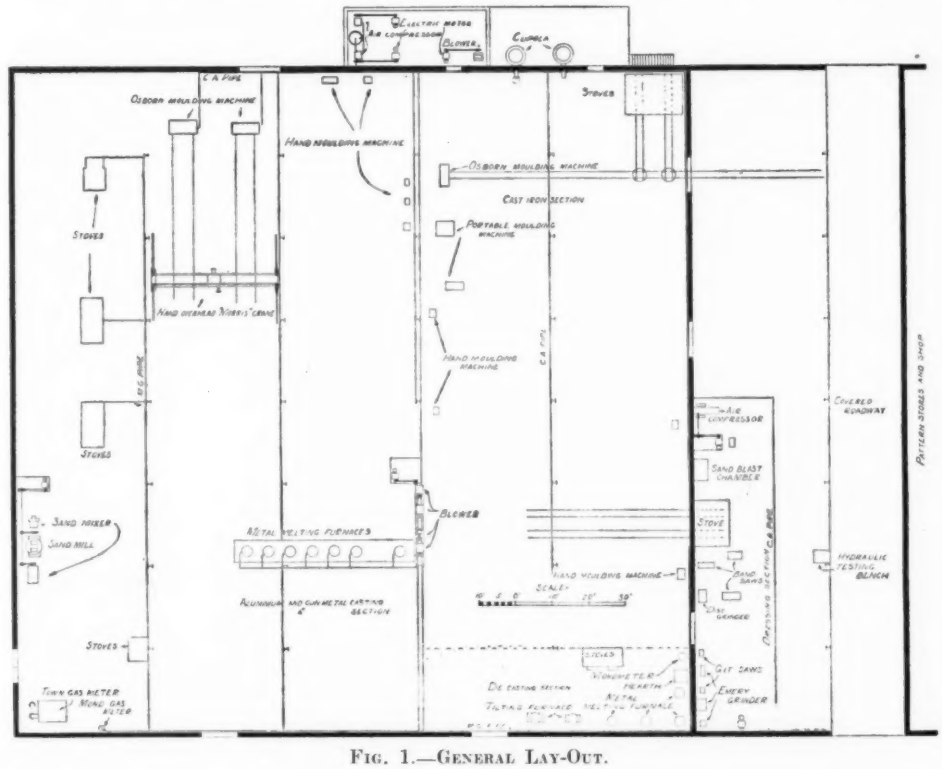

FIG. 1.—GENERAL LAY-OUT.

FIG. 2.—PART OF THE IRON FOUNDRY OF THE SUNBEAM MOTOR CAR COMPANY, LIMITED.

The general layout of the foundry is shown in

Fig. 1, from which it will be seen to consist of six bays. Its general appearance is shown in Fig. 2. The saw-tooth roof ensures both adequate ventilation and lighting. It is 100 ft. wide by 220 ft. long.

Transport.

The transport in an automobile foundry differs from that associated with, say, an engineering or chair foundry, inasmuch as there is but a small weight of metal and other raw materials to be handled as compared with the number of men employed, which in this case numbers about 300.

A 2½-ton overhead travelling crane, by Morris, of Loughborough, is installed. Ground transport is effected by electrically-operated bogey-wagons by Messrs. Heenan & Froude, Limited, of Worcester. These have a carrying capacity of 11 cwt., and are provided with a duplicate set of accumulators, which allows of the truck being in constant operation.

Output.

The foundry regularly manufactures grey iron, gun metal, brass, aluminium bronze, aluminium, and white metal, the last three being very often die cast.

Patternmaking.

One is apt to associate with an automobile factory a very small, yet efficient pattern shop. But as regards size this does not apply to the Sunbeam Works. As will be seen from Fig. 3, the pattern shops are both extensive and wonderfully well equipped. Both the band saw and circular saw are by Messrs. J. Sagar & Company, of Halifax, which firm is also responsible for three out of the four lathes installed. The fourth one has been supplied by the Oliver Machinery Company, of Manchester. These two firms share the balance of the equipment, which includes trimming, gauge, sharpening and setting. The pattern-shop manager depreciated the use of sand papering machines as tending to slovenly work. We can congratulate him on producing patterns, which are seldom equalled. If a pattern is for a repetition job, then mahogany fillets are used, to the exclusion of leather. If, however, the pattern is only to be used a few times, use is made of Plastic Wood. All patterns are clear varnished, and no red paint is used. Metal reinforcements are used, where necessary. Some 40 patternmakers are constantly employed.

Fig. 3.—The Pattern Shop of the Sunbeam Motor Car Company, Limited.

Fig. 4.—The Laboratory of the Sunbeam Motor Car Company, Limited.

Chemical Control.

The department is provided with an excellently-equipped laboratory, a general view of which is shown in Fig. 4. It is supplemented by a mechanical testing laboratory, equipped with a Buckton 50-ton tensile, transverse and crushing machine, Izod impact, Brinell hardness testing and torsion testing machines.

Sand Preparation.

The ordinary facing sand for grey iron castings is made up and varied from casting to casting and from time to time as conditions warrant. It is prepared in a Jackman 6-ft. over-driven mill. In core making Southport sand is used. It is mixed

with Glyso in the proportion of either 15 to 1 or 25 to 1, according to the nature of the job. It is prepared by mixing 5 cwt. lots in a Fordath mixer for 5 minutes. The sand is not dried before use. Though the writer prefers to use dried sand, it should be stated that excellent results are being

FIG. 5.—THE DIE-CASTING PLANT OF THE SUNBEAM MOTOR CAR COMPANY, LIMITED.

produced, and it is a good motto in core shop practice to let well alone. For cores for aluminium castings a local red sand mixed with sawdust is used.

Furnace Plant.

The grey iron melting is carried out in two cupolas, which are worked alternately. One is a Whiting, by Messrs. J. W. Jackman & Company, of Manchester, having eight tuyeres, and the other by the Constructional Engineering Company, of Birmingham, this having six tuyeres. They are blower-driven, actuated by a 6-h.p. E.C.C. motor. Norths Navigation coke is used, which the Sunbeam laboratories show to contain 6.0 per cent. ash and 0.6 per cent. sulphur.

Though the works is not particularly favourably situated for railway facilities, they are fortunate in having a communal supply of Mond gas, which is used for melting the nine 200-lbs. pots for non-ferrous castings and for the cast-iron tanks for melting aluminium and white metal. It is also used for heating the mould and core-drying stoves. The mould stoves are by Messrs. Goodyear, of Dudley, and are loaded by trucks mounted on rails. Core ovens, of which there are several, have been installed by Messrs. John Wright, Limited, and Messrs. C. Portway & Sons, Limited (Tortoise).

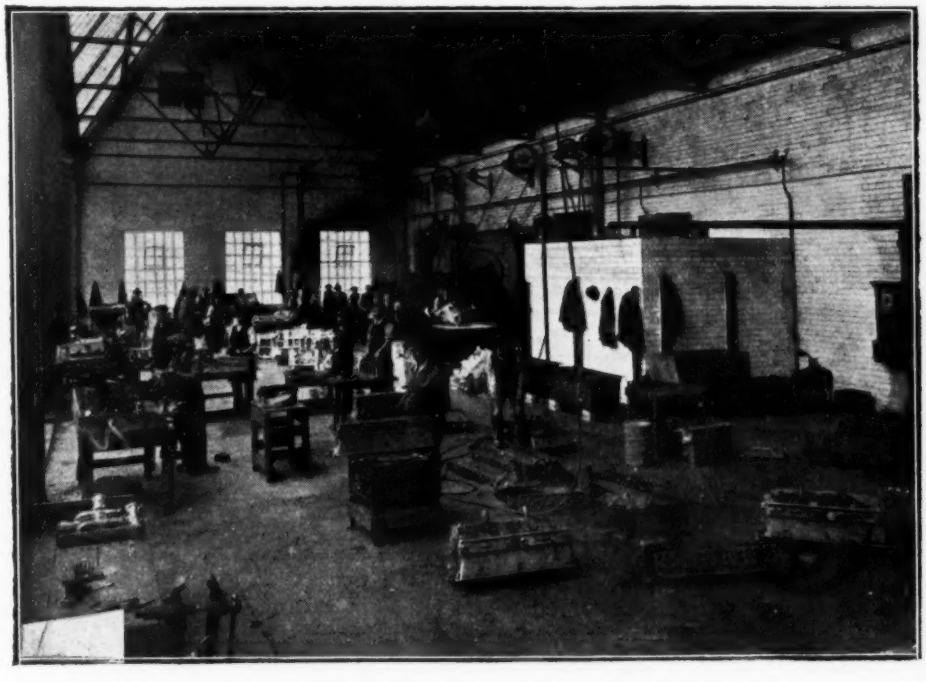

FIG. 6.—THE FETTLING SHOP OF THE SUNBEAM MOTOR CAR COMPANY, LIMITED.

Moulding Equipment.

The foundry is well equipped with moulding

machines. There are three Osbornes (Jackman) roll-over, jarring, stripping machines; two Tabor (MacNab) jar-ramming machines; five Harrison Lincoln and three Britannia. The air is supplied through carefully designed piping from two Broom & Wade compressors, one driven by 25-h.p. B.T.H. and E.C.C. motors.

FIG. 7.—THE DESPATCHING DEPARTMENT OF THE SUNBEAM MOTOR CAR COMPANY, LIMITED.

Grey Iron Castings.

Generally speaking, only two grades of iron are used, that for cylinders containing T.C., 3.4; C.C. 0.55; Si, 1.60; S, 0.07; P, 0.65; and Mn, 0.75 per cent. The ordinary grade analyses work out about T.C., 3.6; C.C., 0.6; Si, 2.2; S, 0.07; P, 0.8; and Mn, 0.6 per cent. The cylinders normally return a tensile strength of 14.5 tons per sq. in. on 1¼-in. dia. bar. A chill test is used in connection with the manufacture.

Non-ferrous Castings.

It is interesting to note that in addition to the usual alloys the Sunbeam concern have developed the manufacture of aluminium bronze made from a mixture containing copper 88, aluminium 10 and iron 2 per cent. This is regularly yielded in the "as cast" condition, 36 tons per sq. in. on a 1-in. dia. bar, and this is associated with a 25 per

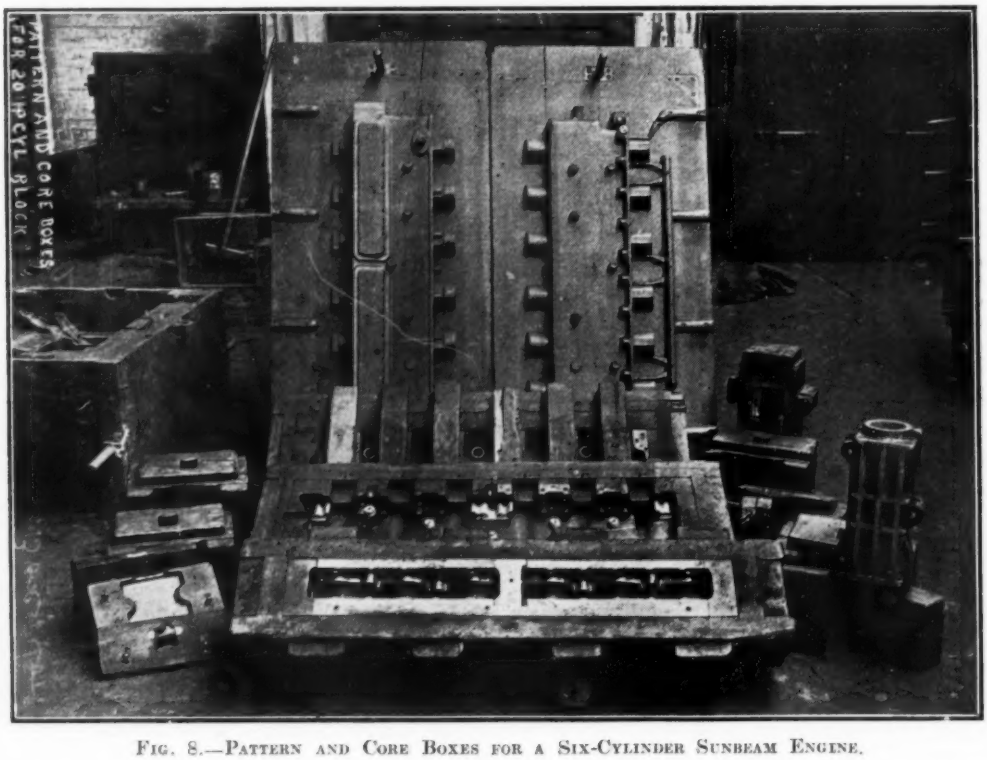

FIG. 8.—PATTERN AND CORE BOXES FOR A SIX-CYLINDER SUNBEAM ENGINE.

cent. elongation. Much success has been achieved with this alloy for die casting.

Die Casting.

The die casting department, which is shown in Fig. 5, is now so well organised that the management state that it is the least troublesome of any

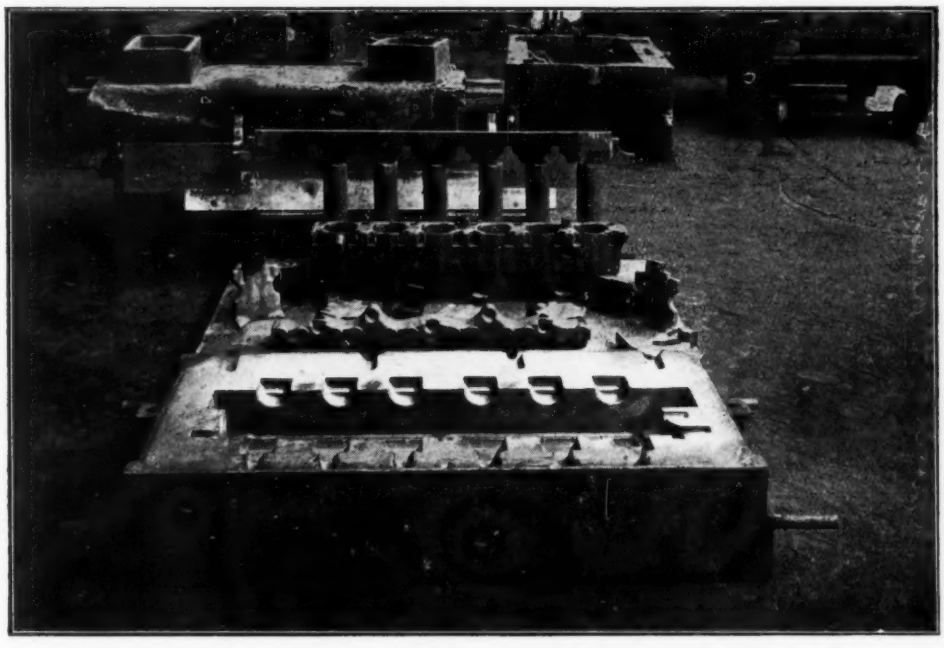

FIG. 9.—VIEW OF HALF MOULD AND SET OF CORES.

associated with the foundry. The Mond gas is here adapted for all the various auxiliary melting and heating units. Numerous white metal cast-

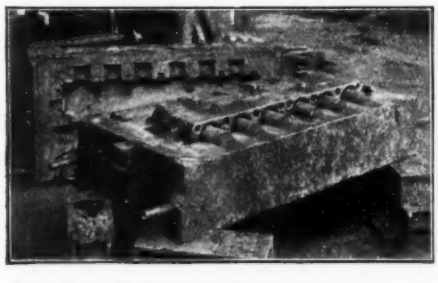

FIG. 10.—SHOWS THE CORES ASSEMBLED IN MOULD READY FOR THE TOP BOX.

ings are made from an alloy containing tin 88, antimony 4, and copper 8 per cent.

Fettling.

The cleaning shop (Fig. 6), which is conveniently situated near the despatching department, is provided with all the latest labour-saving equipment.

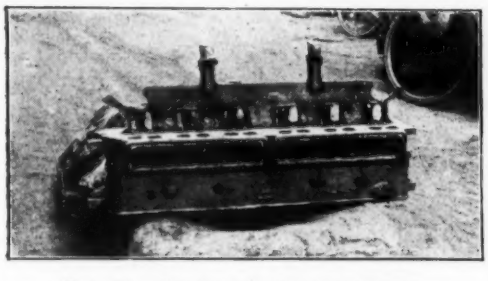

FIG. 11.—SHOWS THE ROUGH CASTING.

Shot blast, band saws, grinders and pneumatic chisels are all used; but, in addition, it is customary to pickle every cylinder casting, afterwards neutralising the acid remaining on the castings by immersing them in a caustic soda bath and a final washing in boiling water. This is a practice which could be usefully followed by other manufacturers whose castings must be free from dirt.

Making 20-60 H.P. Sunbeam Cylinders.

Figs. 8 to 11 show the methods employed in the making of a 20 to 60 h.p. six-cylinder cylinder. Fig. 8 shows the pattern and core boxes. The pattern is in halves dowelled on the plate with the runners to suit. All the core boxes are metal edged, and the bosses, loose pieces, etc., are made of metal. The barrel core box is in metal, with hardened steel bushes.

Fig. 9 shows a half mould and a set of cores. The metal gauges are shown in the background. All cores, after passing the inspection table in the core shop, are located in the moulds by means of metal gauges from the joint of the moulding box. The average thickness of metal is only 5 mm.

In Fig. 10 is shown the assembled mould with the cores in position ready for top box. The six small cores seen on the top are attached to the jacket core to allow for escape of gases and for holding the jacket in position. It also helps with the subsequent cleaning of the casting.

Fig. 11 shows a rough casting straight from the mould, and indicates the position of the runners and risers. It should be compared with Fig. 8.

AT A MEETING of the council of Birmingham University last week it was decided to confer the honorary degree of LL.D. on July 5 next on, among others, the following:—Sir Henry Fowler (chief mechanical engineer, Midland Railway), Emeritus Professor Frankland (formerly Professor of Chemistry in the University of Birmingham), and Mr. F. Gowland-Kopkins (Sir William Dunn Professor of Biochemistry in the University of Cambridge, Huxley Lecturer for 1924).

THE FORTY-SEVENTH ANNUAL DINNER of the Royal School of Mines was held in London on May 20. The toast of "The Royal School of Mines" was proposed by Mr. E. A. Gowers (permanent Under-Secretary, Mines Department), and acknowledged by Mr. H. K. Picard (President). The toast of "The Guests" was proposed by Mr. R. Pawle and acknowledged by Sir Frank Heath (Secretary, Department of Scientific and Industrial Research). The report of the Old Students' Association shows that the membership at March 31, 1924, was 356. The Imperial College Association, on which the Old Students are represented, supported during the year the endeavour of the Imperial College authorities to agree with the University of London in the matter of degrees on a basis satisfactory to the College. This matter is now being considered by a joint committee of the University and of the College.

Moulding Sands for Steel Castings.*

By A. Rhydderch, B.Sc., M.I.Brit.F.

(*Continued from page* 448.)

The Effect of Silt in Moulding Sands.

With the exception of one or two prepared synthetic sands, the writer has not come across any silt contents of greater than 7 per cent., and even the two experimental sands that did contain 14 per cent. of silt gave perfect castings in every respect. In view of this, he is not prepared to say to what extent silt is detrimental, except that it is unnecessary, and if it can be avoided all well and good.

TABLE VII.—*Effect of Clay Grade on the Permeability of Moulding Sands Tested in the Dry State.*

Sand.	Clay. Per cent.	Permeability.	
		Sand.	Sand washed free of clay.
W.Y.	4.4	38	31
S.C.Y.	6.3	235	150
W.R.	7.4	190	115
F.R.	9.3	200	90
H.A.	12.3	280	130
S.C.R.	15.1	120	70
B.Y.	17.0	290	140
B.R.	17.8	150	33

This shows the very marked effect of clay grade in a moulding in closing up the passages for the gases to escape. All the above sands are naturally bonded sands.

Dealing with the grading of sands, it is necessary to grade these sands because it gives a good guide as to the trend of the sand and might eventually be useful. It might also explain why some results, such as variations in strength and permeability, are occurring, and then it is possible to adjust the mixtures accordingly. Regarding the "dye test," the author does not see its utility to the foundry manager. The essential properties of the moulding sand, such as strength and permeability, can be far more readily and reliably measured with simple apparatus.

Preparation of Moulding Sands.

The method adopted in some foundries is too crude for words to express. Silica sand, as received, is thrown into the mill—so many shovelfulls or so many barrows—then so much clay or naturally-bonded moulding sand. All the time the mill is working it is breaking down the silica grains very rapidly, making a much finer mixture. As soon as all the clay or loam is in, the man in charge prepares to open the mill to let it out again; water is added indiscriminately, and it is often carried out by a not-too-intelligent labourer. Oft-times the sand and clay are saturated with water before being put into the mill, and the result is slop and not a facing sand.

Facing sands are prepared for use in the foundry in various ways. First of all there is the old method, still used in many foundries, of treading the sands. Secondly, the introduction of a pan mill, the various constituents being thrown in and milled until the desired toughness is obtained. Thirdly, mixing in an edge-runner mill. Fourthly, proper sand-mixing apparatus, using a paddle arrangement.

But why is it necessary to perform all this operation on foundry sands, even naturally-bonded moulding sands? First of all, to get an even distribution of moisture and bond; secondly, to increase the strength or cohesiveness for use in the foundry; thirdly, to increase the "activity" of the bond itself.

It is well known that nature has not deposited foundry sands in an ideal manner. Various consignments are very irregular even in the case of our best moulding sands. Some are richer in the sand-grade, and at other times richer in the loam-grade. Often one finds solid lumps of the bonding material. This is very noticeable with such a well-known sand as the Worksop red sand. The result of using raw sands containing loamy lumps is very disastrous for the appearance of the casting. In addition, it is very painful for the moulder who uses them. So that, even with the naturally-bonded sands, it becomes necessary to redistribute the clay grade by causing it to coat the silicious grains, thereby carrying out to the full extent what nature has started to do. It is important to know how milling a sand is going to affect strength and permeability. Even a casual examination of the sand with a small magnifying glass shows that the bond is redistributed, apart from what the process of mixing might be.

TABLE VIII.—*Effect of Milling Worksop Red Sand. Top row of Figures Refers to Large Mill; Bottom Row of Figures Refers to Small Mill.*

Time of Milling.	Mechanical Analysis or Grain Size.					Compressive Strength.		Transverse Strength.		(Im) Permeability.		Remarks.
	mm. < 1.0 > 0.6	mm. < 0.6 > 0.25	mm. < 0.25 > 0.1	mm. < 0.1 > 0.01	mm. < 0.01	Wet.	Dry.	Wet.	Dry.	Wet.	Dry.	
Raw sand	3.54	16.58	72.65	2.40	4.93	230	2800	60	950	69	50	Raw sands, very uneven.
	0.63	20.34	69.40	2.78	6.65	155	2050	40	1320	50	39	
5 mins.	0.57	5.13	76.06	5.96	12.28	510	4800	110	1450	87	64	Moisture test gave 4.7, 4.9, 5.1 in small mill.
	0.39	15.12	70.98	3.27	10.17	270	3300	88	1660	50	38	
10 mins.	0.79	5.81	72.65	4.68	16.1	540	5600	130	1820	81	60	Moisture, 5.0, 5.1, even texture.
	0.28	14.85	67.97	5.42	11.44	320	4000	100	2230	52	41	
15 mins.	0.68	6.65	71.85	5.20	15.63	550	5600	155	2250	76	54	Even texture.
	0.25	13.69	67.15	5.17	13.66	400	4030	124	1700	51	40	
20 mins.	0.51	5.88	72.21	5.50	15.87	610	5250	150	1950	77	57	Mixture getting lumpy.
	0.28	14.24	68.13	4.23	13.03	430	3930	155	1730	56	44	
25 mins.	0.61	5.68	71.74	5.68	16.31	640	5240	170	1880	77	57	
	0.26	13.20	69.21	3.7	13.55	480	3760	151	1830	59	47	
	0.81	5.32	71.97	5.5	16.3	630	5700	170	2220	78	58	
30 mins.	0.26	12.99	69.95	3.44	13.36	460	4100	174	1700	61	48	

Compressive and Transverse Strengths in Grammes per sq. cm. Permeability in Seconds.

To consider exactly what does happen in an ordinary milling operation, Table VIII shows what happened to Worksop red sand in a large pan mill holding 10 cwts. The sand was air-dried and a definite amount of water added, then mixed before being put into the mill. It will be seen that the water is not very evenly distributed after 5 min. milling, but after 10 min. it is nearly so, so that the sand in all parts of the mill will contain approximately the same water content.

* A Paper presented to the London and Sheffield Branches of the Institute of British Foundrymen.

The Strength of Sand as Affected by Milling.

It will be noticed that the strength increases very rapidly during the first ten minutes, and then it gradually settles down to an approximately constant value. The permeability certainly becomes a little worse, but the increase is not sufficient to create any difficulties in actual use. In fact, castings made with sands milled for various lengths of time did not show any blow-holes or pin-holes, and, what is more, they all stripped well at the time when the milling was 10 min. or over.

The effect on the grain size is very obvious. Even under these conditions there is a very decided crushing effect, but after 15 min. the crushing effect seems to cease. This undoubtedly is due to the formation of an elastic cushion of bond protecting each silica grain. This is a very important fact to bear in mind. Of course, it might be considered that the increase in strength is also influenced, not so much by the redistribution of the bond as by the variation in grain size, and also probably by the increased activity of the bond. To test this point a silica sand was graded into four parts in accordance with Table IX, and the mixtures made were tested by the ordinary transverse method.

TABLE IX.—*Effect of Grain Size on Strength of Sands.*

	Breaking load.
1. Through 10 mesh on 20. ..	95 grams
2. ,, 20 ,, 40 ..	100 ,,
3. ,, 40 ,, 60 ..	120 ,,
4. ,, 60 ..	135 ,,
Sand used—Crushed Silica rock:	
Bond:	10% Derby clay.
Water	5% ,,

Hand mixed for 10 minutes. This shows that it is not the thickness of the bond round each grain that gives the strength, but the surface contact, because the finer sand has a very much greater surface area than a coarse sand.

Part 1 broke at 95 grammes, part 2 at 100, part 3 at 120, and part 4 at 135. That is, the finer the grading the stronger the sand with the same amount of bond and water, so that although the coarser sand has the least surface area and therefore the greater thickness of bond on its surface, yet the finer sand with the greatest area, and therefore the greatest number of points of contact, shows the greater strength. This leads to the conclusion that in the preparation of sand a thin coating of clay is required on the grain, and that it is the surface contact and not the thickness that gives maximum cohesiveness. What this actual minimum thickness is, the author is not prepared to state without further experiment.

TABLE X.—*Effect of Milling French Red Sand. In a Small Pan Mill—One Plain, One Grooved Roller.*

Time of milling.	Grain Size.			
	< .6 mm. > .25 ,,	< .25 mm. > .10 ,,	< .10 mm. > .01 ,,	> .01 mm.
As received	11.6	74.1	2.0	11.3
5 mins.	9.9	76.5	1.8	11.7
10 mins.	7.2	78.0	2.9	11.6
15 mins.	7.4	78.3	2.0	12.0
20 mins.	8.6	76.5	2.2	12.0
30 mins.	9.0	75.6	2.3	12.8

The raw sand was tempered with 5% water and allowed to stand 6 hours before milling.

This result is extremely interesting because under these conditions we do not find a great deal of grinding, but simply a coating of the grains.

Table VIII shows a similar Worksop red sand which was milled in a very much smaller and lighter mill; one roll being plain and the other corrugated. Here again the effect on strength and permeability is very much the same, but the crushing effect is not nearly as serious. In other words, the smaller mill is more efficient in its redistribution of the bond than the larger mill. It will also be noticed that in this case the grain size reaches a constant value after about 15 min. milling. This, in the author's opinion, is one of the most interesting facts in connection with the question of milling sand, and the old idea of the continuous breaking down of the sand grains is obviously a fallacy; at any rate under these particular conditions. In order to test the breaking down of the sand grains in milling and how far it is affected by the amount of clay grade and moisture present, a French red sand was tempered with water and then milled in the small mill under the same conditions as the Worksop red sand. French red sand was selected because it contains a much higher clay content than Worksop red sand, and it is generally better distributed over the silica grains. Table X shows that the effect on the grain size is almost negligible, so that under these conditions the effect on the grain size can be controlled.

Amounts of Moisture Necessary for Naturally-Bonded Sands.

At the present time, the method in use is simply to temper the sand until the sand is cohesive enough to hold together without leaving a sticky mess on the hands. What controls the amount of water that a sand will hold before it reaches its sticky state? By adding increased percentages of water to various sands, it has been shown that the strength gradually increases until it reaches a maximum, and then it gradually falls away. In other words, every naturally-bonded moulding sand has an optimum water content. Generally speaking, it can be stated that those with a ferruginous bond have a much higher optimum water content than those with a clay bond, that is, of course, assuming the same percentage of bond present. The amount of moisture required to produce this maximum strength can vary between 2 to about 40 per cent. of the clay grade present. Naturally, one would say at first glance that this is the best amount of moisture to add, but it is probable that the best practice is to work with the sands slightly on the dry side rather than to aim at the optimum water content. Tests on sands will bear this out, as mentioned previously.

The Mobility of Clay in Moulding Sands.

In view of the rapid strides that are being made in steel foundries in the use of green-sand moulding, the question of a correct amount of water to be added for each particular sand should be carefully investigated and determined. By means of methods of testing already described, it should be easy for any foundryman to determine the maximum permissible amount of water to be added to any of his facing-sand mixtures, and for uniformity of results it is fairly obvious that the amount of water in the sand should be kept within fairly definite limits. Now that the amount of water to be added has been fixed, the natural question that arises is how and when should it be added. From the above results relating to the effect of milling in crushing sand grains, it is obvious that the sands should be dry, mixed very thoroughly, and then a correct amount of water added. It must be borne in mind that there is a time-factor in the penetration of water into any loamy material, and during this penetration the sand gradually and steadily swells and increases in volume. The clay grade becomes more mobile, and upon the slightest application of pressure or rolling will spread very easily, so that when a sand is dry-mixed, the water added, and then allowed to stand for a matter of, at least, a few hours, there is a better chance when it is put into the mill of avoiding any alteration in the grain size. In fact, nothing would be lost by letting it stand even for a few days, so as to even up the moisture content of the whole mass. But even after milling a very large number of sands show loamy particles distributed very freely amongst the sand grains; that is, there has not been sufficient mobility in the clay grade itself to enable it to be easily spread. This is particularly so in the case of the synthetic sands. How often does one find, on examining a fire-clay by sieving, that a very large amount of the clay, after washing for many hours, is left in large lumps. Even after milling the same condition persists, so that the efficiency of the added clay is often not greater than 20 per cent. The object must be, therefore, to assist in the distribution of this bond by some means. It has already been suggested that this is aided by allowing the mixture to stand, and now we require some further aid. Here we can consider the action of alkalies and acids on clays. It is a well-known fact that alkalies and acids have very profound effects on the properties of clay; in fact, use is made of this point in the ceramic industry. The alkalies seem to loosen all the clay particles, thereby increasing

their mobility or increasing their fluidity. Having thus separated the large lumps of clay into fine particles, it seems to protect them, causing the clay grade to remain in suspension instead of coagulating. Surecht found that the elasticity of a clay could be increased nearly four hundred per cent. by the use of suitable quantities of various alkalies, so that clay grade or coagule grades, as we consider them, will be spread much more easily by suitable treatment with alkalies. Only fractions of 1 per cent. are required to bring this about.

This principle has been used in some German and American foundries with the idea of revivifying used milling sands, and the results are stated to have been satisfactory. So that the first method considered is that of the mixing of the ingredients perfectly dry and then adding a very diluted alkaline solution to bring about the necessary mobility, and that this action will be considerably aided by allowing the mixture to stand at least a few hours before milling. This method can be described as the dry method.

The alternative method is the wet method, which has also been used in the preparation of synthetic sands. Here the plastic fireclay added is made into a slurry and emulsified and then added to the silica sand already in the mill. It is obvious that, unless there is sufficient clearance in the mill, a very great crushing action will take place before the grains are sufficiently coated to behave like rubber balls. Probably a better procedure would be to mix the fireclay-slurry with a silica sand in an ordinary paddle-type of machine, allow to dry, and then re-temper to the correct moisture before putting it in the pan mill. This procedure can be made infinitely better by reducing the bond added to a true colloidal state by means of some of the machines now on the market. The one thing that foundrymen must attempt to do is to coat the grain with a thin, even layer of bond without crushing the silica grains, resulting in the most cohesive sand compatible with the maximum permeability.

It is obvious from the remarks that have already been made that for uniformity of work and product it is essential that the distribution of the bond, the amount of moisture, and the grain size should be controlled, and that work must be directed in the direction of producing moulding sands of maximum permeability with the necessary cohesive strength.

Floor Sand.

The most perfect facing sand behaves just the same as the worst if a very inferior floor sand is used for backing. Consider a mould with, say, 10 in. of sand from the pattern to the edge of the box, the permeability of the facing sand can be considered to be 50, that of the floor sand 200, so that using 1 in. of facing sand and 9 in. of floor sand as a backing, a resultant permeability of 185 is obtained. In addition, the moisture in the floor sand is oftentimes very uneven, the bond irregular and weak. Numerous troubles are due to the quality of the backing sand, and every foundry should, in its own interest, control this point very carefully. Regarding the use of floor sand in facing mixtures, its strength and grain size should be carefully noted if it is desired to produce a standard facing sand.

Preparation of Compos.

With reference to the preparation of compos, here again the most important point is to keep close control of the grain size and, further, to ensure an even distribution of the clay added. In preparing crushed pots, etc., it is essential that a perforated pan be used, so that the finer materials are rejected immediately on formation. This will help to keep down an excessive formation of dust. The crushed rocks should then be graded through sieves or riddles and the dust blown away in an air channel. The bond is probably best added in the form of a slurry, the whole mass turned over by hand or mixed in revolving drums. This having been done, it is probably advisable to allow the whole mixture to dry and re-temper to a suitable consistency. If put in a pan mill, there should be ample clearance between the rolls and the bottom of the pan, so as to ensure no further crushing. The underlying idea here is to obtain a definite grading of the material and to ensure each grain being well coated with its bond.

Most compos are very variable in grain size, and on the whole highly impermeable to gases. This is due to the uneven grading of the moisture.

Before leaving the question of compos, it should be stated that there is an economical limit to the maximum size of the grains in a compos used as a facing mixture. If too coarse, then the face is likely to be easily disintegrated during casting, resulting in excessive fettling costs. As a general rule, it may be stated that the coarsest particles should not exceed $\frac{1}{8}$-in. dia., or about 3 mm. dia., the remainder being suitably graded to give the required permeability.

Drying of Sands and Compo Moulds.

In considering this question, foundrymen must bear in mind two points. First that a very large amount of drying is done on machine-made moulds,

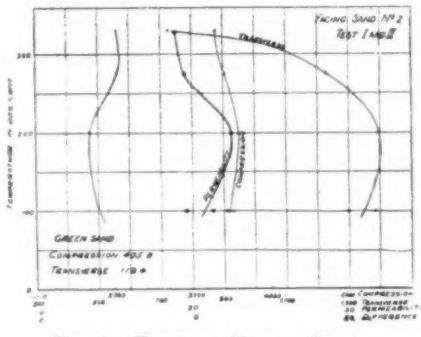

FIG. 4.—TESTS ON FACING SANDS.

because the work is carried out by unskilled labour and drying is therefore more a precaution than a necessity. Further, most work that has to be machined is dried to make sure of soundness in the machined parts. Most of this class of work is dried between 200 and 300 deg. C., irrespective of the sands used. With the larger work, we not only get drying, but even calcining and compos are stoved to 500 or 600 deg. C. Before the war, at Krupps, compo-moulds were even drawn at a red heat, but the question that interests us is, what happens on drying a mould? A few tables have already been shown where the strength and also the permeability, after drying at 100 deg. C., have been recorded.

Fig. 4. shows the results obtained on a synthetic mixture of silica sand and a fireclay. It will be seen that on drying at 100 deg. C., the strength has been increased from 260 grs. per sq. in., to 3,400 grs. to the sq. in., and it is practically unaffected to about 200 deg. C. On further heating, the strength gradually gets less, but the decrease is not serious and the permeability is even less affected. This falling off in strength is probably due to the contraction of the clay film round the grains, thereby setting up fissures of weakness. Regarding the effect of drying on permeability in

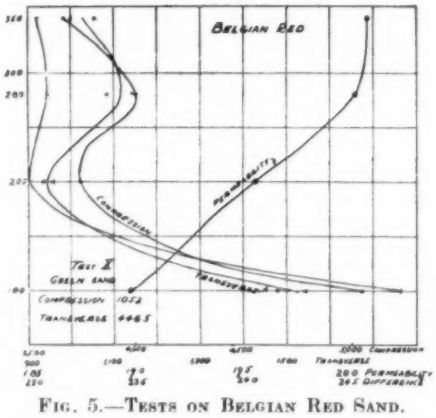

FIG. 5.—TESTS ON BELGIAN RED SAND.

general, it can be said that drying a sand increases the permeability very considerably, an improvement of 50 per cent. being easily obtained in some sands. In practice the difference is probably still greater because the hot gases

emanating from a green sand mould will naturally evaporate the water in the sand, setting up a much greater resistance than happens under the conditions of our test.

With regard to the strength of sands on drying, this is increased from 2- to 20-fold, depending first upon the amount, and secondly upon the nature of the bond present.

Fig. 5 shows the effect of heating of Belgian red sand. It will be noticed that the behaviour of this

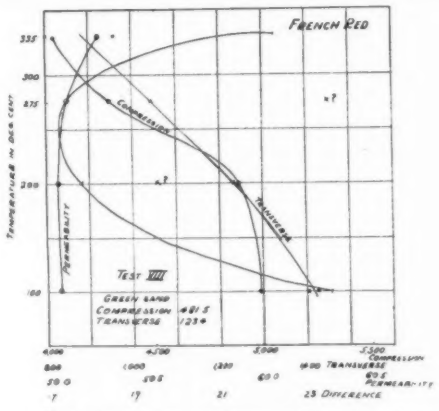

FIG. 6.—TESTS ON FRENCH RED SAND.

sand is quite different from the previous one, and that, after 100 deg. C., there is a well-known fact that these naturally-bonded sands are much more easily burnt than those made of a silica sand and fireclay, and we have here a probable explanation of the cause.

Fig. 6 shows the effect of drying French red sand, which behaves in a very similar manner to Belgian red sand, although the loss in strength is not nearly as serious. For some unknown reason Worksop red sand does not show this behaviour to nearly such a marked extent. Up to 300 deg. C. there is hardly any change in the physical properties of the sand. Of course, there is less bond in Worksop sand than in French—probably this has something to do with the explanation, and also the amount and nature of the colloids. If moulding sands are tested for strength and permeability when hot, they give a very different figure from that obtained when cold. The sands are very much stronger, as much as 20-30 per cent., and more impermeable.

The conclusions to be drawn from this paper are that sands with a large amount of bonding material deteriorate much more rapidly on heating above 100 deg. C. than those with a small amount of bond, and that naturally-bonded sands show this behaviour in a very pronounced manner. Further, those with a fireclay bond will stand a great deal more fire than those with a natural bond or a ferruginous bond.

For the fixing of temperatures for drying ordinary moulds of naturally bonded sands or synthetic sands, it is not advisable to go beyond 205 deg. C., except in special circumstances where the mould has to contract under the action of the steel. In such cases, it might be necessary to go as near the rotting point as possible, but it must always be borne in mind that if the skin of these moulds is broken, patching is impossible, and the result is invariably a dirty and unsound casting. A sounder way is to arrange cavities in the mould and to dry at temperatures not exceeding 300 deg. C. It is to be regretted that the expansion or contraction of these sands was not determined during these experiments, but it is a fact that silica sands do expand and the size of moulds when dry and when green is seldom the same. One can see this daily in any foundry. Cores will not go into core-prints without filing or rubbing. Weights of castings very often differ, though the green-sand moulds are of the same measurement, this being due, of course, solely to the different temperatures at which the moulds were baked. In fine work, the question of the variation in the size of the moulds becomes an important point.

Regarding the rate of drying, this depends on the mass of sand to be dried. The larger the mass, the slower the drying. Further, the moulds must be very well vented to allow the steam to get away easily, otherwise badly cracked moulds are produced. In compos, this excessive cracking can also be caused by an excessive amount of fireclay ingredients, and it is obvious that if the fissures or cracks are of large dimensions, then the size of the mould must vary very considerably from what it should be, in fact, it is even possible to find a mould so changed in shape that the machining allowance has generally disappeared.

Regarding the drying of moulds generally, the points to bear in mind are to dry slowly and well vent all the moulds and, further, to keep the temperature of drying under close control.

Conclusions.

From the data given in this paper, it is fair to say that with our present information, and methods of testing, we are in a position to obtain reliable data regarding sands used for moulding purposes, and by a series of routine tests—all of a simple character—close control can be kept of the mixtures used. This will undoubtedly assist foundrymen in the tracking down of many mysterious foundry troubles.

Emphasis has been laid on the question of moisture in sands: Too little attention is paid to this side of the question, and this, in spite of the fact that a wrong moisture content can make a good sand a bad one.

The question of more careful control of floor sand has been touched upon, and it has been pointed out that numerous sand troubles are due to this and not to the facing sand.

The author has not seen many results on the drying of sands, and the effect of such drying on the properties of the sand. These results are, therefore, put forward in the hope that they will give all foundry workers some idea as to what happens on drying a moulding sand. An attempt has also been made to study the effect of milling sands, and it is hoped to investigate this question much more fully at an early date, especially in view of the interesting results obtained.

All foundry workers are searching for the ideal moulding sand—the panacea for all foundry evils—and it is hoped that the results presented in this Paper will be of some assistance to those workers.

It can be stated briefly that some of the essential properties of this ideal sand are:—

(a) That it be highly permeable if open to gases, and what is more important, the rate of increase of permeability with density of ramming or hardness should be low.

(b) It should also develop maximum strength, suitable for moulding, with a minimum amount of moisture.

(c) The bond should be mobile, that is, it should be easy to develop maximum cohesiveness with slight mechanical preparation.

Many other conclusions can be drawn from the published results on the properties of moulding sands, but in our interests it is essential that we should immediately agree upon some definite standards which are helpful to all foundrymen. Unfortunately, we have no fixed standard of testing, resulting in a great deal of confusion and, what is more unfortunate, in the inability to co-ordinate the various results published.

It is only by co-ordination that we can hope to make progress, and it behoves us, in our own interests, to take this matter in hand and decide on some definite standard for reference.

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North African Iron Ores.—The Compagnie des Minerais de Fer Magnétique de Mokta-el-Hadid reports for 1923 for the Benisaf Direction an output of 381,531 tons of ore and sales amounting to 521,440 tons, the excess amount having been taken from stocks. As in previous years, the bulk of the shipments in 1923 went to Great Britain and France, and a very small quantity to Germany. A large quantity of smalls were shipped to the United States.

XUM

The Production of Castings in Permanent Moulds.*

American Exchange Paper.

By Robert J. Anderson† and M. Edward Boyd.‡

INTRODUCTION.

In the production of castings, interest has always been shown in attempts to devise and employ moulds that would be permanent or semi-permanent in nature, thereby eliminating the procedure of destroying the mould with every pour, as in sand practice. In connection with an investigation carried out in the U.S. Bureau of Mines on the production of aluminium-alloy motor pistons in permanent moulds,[88] study was made of the permanent-mould process in general, and more particularly of its application to the aluminium-alloy field. Permanent moulds are now employed in many branches of the foundry industry, and in the present Paper it is the writers' object to discuss permanent-mould casting in general, and to point out the applications and limitations of the process as compared with other casting methods.

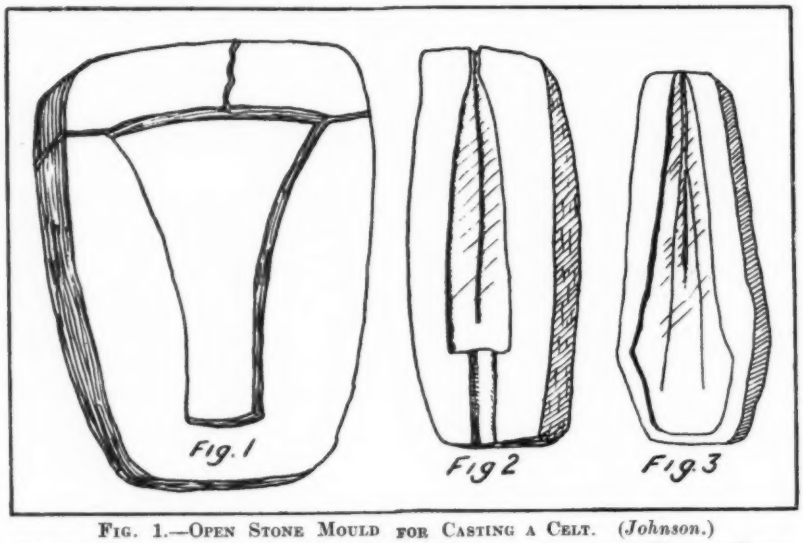

Fig. 1.—Open Stone Mould for Casting a Celt. (*Johnson.*)
Fig. 2.—Half of Compound Stone Mould, Used for Casting a Tanged Knife. (*Johnson.*)
Fig. 3.—Half of Compound Stone Mould, Used for Casting a Dagger Blade. (*Johnson.*)

The principles involved in the production of castings in permanent moulds (*i.e.*, metallic moulds) have been known and practised since 3,000 B.C., but the cast-iron mould as it is known and used to-day has been employed only about 150 years. Moreover, the creation of permanent-mould casting as an important and separate industry is a relatively recent achievement. The permanent-mould casting of metals and alloys antedates sand casting by thousands of years, and stone and bronze moulds were employed by pre-historic man for casting weapons, ornaments, and tools. As indicated, the use of permanent moulds is desirable since in sand practice each mould is destroyed on pouring, and producers of castings desire moulds which can be used over and over again. The principal advantages of permanent-mould casting over sand casting may be summed up as follows:—(1) Permanent-mould castings are more accurate and uniform as to size and weight tolerances; (2) machining may be either greatly reduced or eliminated entirely; (3) permanent-mould castings have better surface appearance, are more sound, and have better mechanical properties; (4) the permanent-mould process is continuous, the output is normally more rapid than in sand casting, and production costs are lower; (5) unskilled labour can be used instead of skilled moulders; and (6) often parts that could not be made in sand can be made in permanent moulds.

The question of machining costs is especially important in the production of modern metal manufactures, and any process which will ensure lowered machining costs deserves especial consideration. Practically any mechanical part, unless too large or involving exceptionally complicated coring, can be made by permanent-mould casting, and such castings may be practically finished parts as they come from the mould, except for the removal of gates and fins and dressing on some surface. The requirements of the automotive industry for large numbers of small interchangeable castings offer a particularly adaptable field for permanent-mould casting, and at the present time a number of different castings for use in automotive construction are being produced in permanent moulds.

Acknowledgments.—The writers wish to acknowledge with thanks certain information supplied by concerns employing the permanent-mould process and by metallurgists and engineers connected with these companies. Certain photographs of French permanent moulds were supplied by Dr. Léon Guillet, and photographs were loaned by Dr. G. M. A. Richter, of the Metropolitan Museum of Art; Dr. C. W. Mead, of the American Museum of Natural History; and Dr. B. Lanfer, of the Field Museum of Natural History. Other acknowledgments are made specifically in the text.

History of the Permanent-Mould Process.

While the history of casting metals and alloys is of unusual interest to the academic metallurgist and also of more general interest in tracing the development of foundry practice, the subject can be dealt with only very superficially here. So far as is known, casting in permanent and semi-permanent moulds antedates sand casting by thousands of years, and very early in the development of pre-historic man stone and bronze moulds were employed for forming tools and implements of warfare. According to Moldenke,* "so far as actual evidence is concerned, mention has been made of the ancients casting iron, and unquestion-

* Published by permission of the Director—U.S. Bureau of Mines.
† Metallurgist, U.S. Bureau of Mines, Experiment Sta., Pittsburg, Pa.
‡ Formerly Asst. Metallurgist, U.S. Bureau of Mines, Experiment Sta., Pittsburg, Pa.

* Private communication, R. Moldenke, Dec. 24, 1923.

ably in green-sand open moulds, but the art was lost during the early periods of history. The first mention of actual castings which can be documented is in 1370 A.D., in the testament of the Bishop of Poitiers. Here, unquestionably, the reference is to green-sand castings." So far as is known, the process of casting in permanent moulds dates back to the early Bronze Age (3,000 B.C., at least), and the methods of casting as employed by the pre-historic founder have been very well discussed by Johnson.[24]

The first moulds employed by early founders, so far as is known, were very crude open moulds, formed of clay and burned hard. Such moulds were probably only semi-permanent and withstood only a few casts; very few of them are in existence to-day. Probably almost contemporaneous with the open clay mould, and doubtless the original precursor of the present-day permanent mould, was the open stone mould. Large numbers of these moulds have been found in the excavation of ruins, and are in the possession of the British Museum and other museums. These moulds were made by gouging out a cavity in the face of a soft rock, such as sandstone, micaceous slate, or soapstone, and most of them are of very simple design. Such castings as flat axes and celts were poured in the open stone moulds. By pouring copper or bronze into these moulds, simple weapons could be formed, and usually these were given further shape by hammering and then sharpened on a stone. Open stone moulds have been found in Ireland and England. Fig. 1 shows an open stone mould used for casting a celt. This mould was found near Ballymena, County Antrim, Ireland.

Following the open stone and open clay moulds came the compound clay and compound stone moulds. These compound moulds were parted in halves, and some of the specimens found exhibit truly remarkable skill and ingenuity in design by the prehistoric founder. The mould cavity and

FIG. 4.—HALF OF AN OPEN STONE MOULD FROM ISLAND OF CRETE. (*Courtesy, Metropolitan Museum of Art.*)

gates were cut in the two halves of the moulds, and these early moulds are similar in principle of design and operation to present-day permanent moulds. Fig. 2 shows half of a compound stone mould used for casting a tanged knife, and found near Ballymoney, County Antrim, Ireland. This mould was cut in close-grained sandstone. Fig. 3 shows half of a similar mould used for casting a dagger blade. The compound stone mould was developed to a high state of perfection, and was employed for casting daggers, sword blades, spear heads, and other weapons, as well as tools. Fig. 4 shows half of a compound stone mould obtained from the island of Crete; this mould was cut in steatite (a massive variety of talc, known usually as soapstone). Stone, terra-cotta, and some sort of wax moulds were used by the ancient Peruvians,* and Fig. 5 shows a gold figure with filigree work, cast in Colombia, probably in a wax mould. It should be pointed out that the filigree work on this object was not soldered on, but is an integral part of the casting.

Following the stone moulds, and marking another advance in the progress of the ancient founder in the art of casting, came the bronze moulds. These moulds were first copied from the earlier stone moulds. Bronze moulds withstood the erosive action of liquid copper and bronze better than the clay and stone moulds. Bronze moulds have been found in large numbers in Northern France and in England, and they were used for casting celts, daggers, gouges, palstaves, and other weapons, and tools. In these moulds there is shown a tendency toward more complication in design and in character of castings made. Fig. 6 shows a bronze mould used for casting gouges; this was found near Plenée Jugon, in Brittany. The two halves of the mould are shown in the figure. This

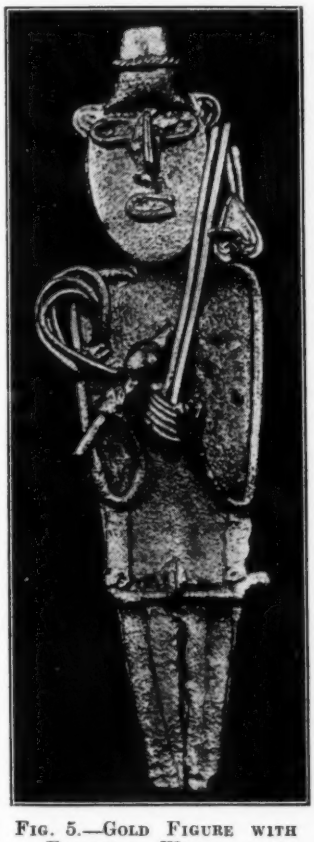

FIG. 5.—GOLD FIGURE WITH FILIGREE WORK FROM COLOMBIA. (*Courtesy, American Museum of Natural History.*)

was a cored mould, and, when put together, a bronze pin was inserted through the transverse hole shown in the left-hand half to keep the core in place on casting.

In Fig. 7 is shown, at the left, one-half of a copper mould used for casting a spear, and, at the

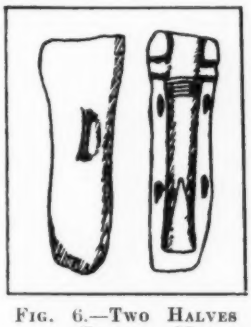

FIG. 6.—TWO HALVES OF BRONZE MOULD FOR CASTING GOUGES. (*Johnson*).

right, the spear cast therefrom. The mould was obtained* at Si-anfu, China, and apparently dates from the third or second century B.C. As will be seen, there are small knobs along the edge of the mould half in the left of Fig. 7, and these apparently were to fit into holes in a corresponding half. Plaster halves were made up from the

Private communication, C. W. Mead, Dec. 26, 1923.

* Private communication, B. Lanfer, Jan. 29, 1924.

original half at the Field Museum of Natural History, and the spear shown in the right of Fig. 7 cast therefrom.

The guide to the antiquities of the Bronze Age in the department of British and Mediæval Antiquities of the British Museum[1] gives considerable information as to the types of castings produced by the prehistoric founder.

The discovery of iron and steel and the employment of these materials for weapons and implements required new methods of founding, and resulted in the employment of the sand mould. While the use of permanent moulds was not extensive for many years co-existent with the sand mould, the desire for moulds which would withstand more than one cast again asserted itself in modern times, and, early in the 19th century, patents bearing on the subject began to appear. The casting of iron and steel in permanent moulds presents greater difficulties than that of the non-ferrous alloys, and the process of casting ferrous alloys has been relatively slow in developing. However, the process of casting in metallic moulds—*i.e.*, steel or cast-iron moulds—has now been fairly fully extended to include all kinds of ferrous and non-ferrous alloys, and at the present time practically any type of alloy can be cast in a permanent type of mould. The permanent mould has been attracting much interest in recent years in connection with the centrifugal casting of iron and steel, but from the mould so that the chilling effect is stopped, and then the casting is allowed to cool in air. Radiators, brake-shoes, cylinder blocks, and other cast-iron parts have been produced by the permanent-mould process. Just recently, a process for producing cast-iron parts in permanent moulds has been developed by the Holley Carburettor Company,[49] in which a so-called long-life mould is employed. The mould is made of ordinary grey iron, but a thin retractory lining made of ball clay and sodium silicate, or other suitable material, is applied to the face of the mould, and this lining is covered with a thin coating of amorphous carbon. The process of the Holley Carburettor Company is used at its plant for the production of cast-iron carburettors, and at the Ford Motor Company for the production of cast-iron pistons.*

In the non-ferrous field, the permanent-mould process is used for casting brass, bronze, aluminium bronze, and light aluminium alloys, and it can be adopted for the production of castings in any of the usual commercial non-ferrous alloys. The process has been employed very largely in the aluminium-alloy field for making pistons.[50] In a later section of the Paper the various kinds of alloys used in permanent-mould casting and the types of castings made will be discussed, and the applications of certain variations of the permanent-mould process to the production of certain types of castings will be taken up in the following section.

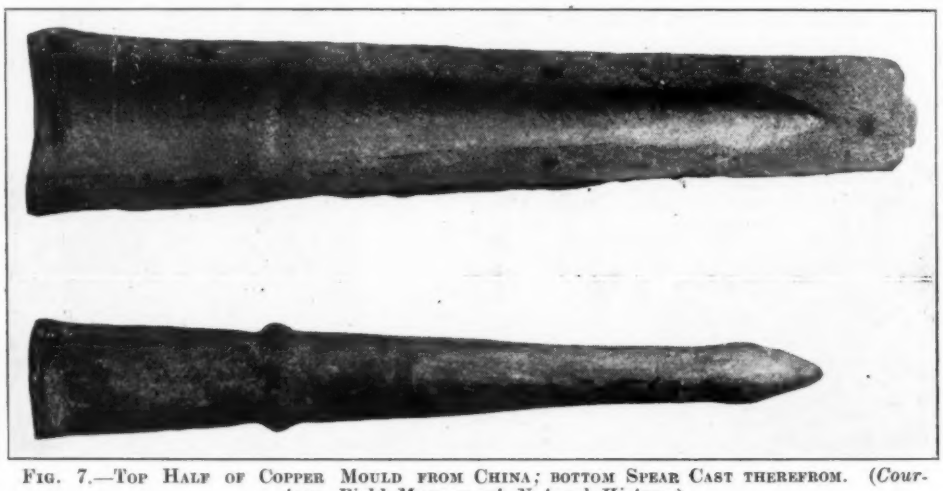

FIG. 7.—TOP HALF OF COPPER MOULD FROM CHINA; BOTTOM SPEAR CAST THEREFROM. (*Courtesy, Field Museum of Natural History.*)

the permanent-mould process has not been used extensively for iron because of inherent difficulties involved.

The development of permanent-mould casting has progressed more rapidly in the non-ferrous field than in the ferrous, due largely to the fewer difficulties encountered in the former. However, even in non-ferrous castings, commercial production has been limited more or less to small castings of simple shape, although such castings as complicated motor crank-cases have been cast in permanent moulds using sand cores. As will be indicated later on, various modifications of permanent-mould casting, including die casting and Cothias casting, comprise separate industries, and the die-casting industry is operated on a large and profitable scale in the United States. Referring to iron castings, small articles of cast iron were made in permanent moulds for many years, but these were invariably chill hardened, and consequently unmachineable. About 1902 work was begun by Custer[3 5 10 11] with permanent moulds at the Tacony Iron Company, Philadelphia, Pa., and a process was developed for casting sewer pipe, sash weights, pipe fittings such as Y and T sections, and other simple parts. In the production of sewer pipe, an arrangement of 30 moulds was mounted upon a revolving table and 240 pipes per hour were cast. The table carrying the moulds was operated mechanically in such manner that each mould was poured every 7-8 mins. The success of the process devised by Custer for avoiding the chilling of iron when cast in an iron mould depends upon the method of operation; in the process the iron is rapidly chilled to the freezing point by the mould, and then immediately removed

Types of Processes Involving the Use of Permanent Moulds.

At the outset, in discussing the permanent-mould process for producing castings, it is important to state that there are five essentially different commercial processes which involve the use of cast-iron or steel moulds. In trade parlance, there is considerable confusion in the use of terms applied to describe the castings made by these different processes, and it is accordingly desirable to distinguish sharply among them. The five processes involved are the following, viz.: (1) Die casting; (2) slush casting; (3) Cothias casting; (4) centrifugal casting; and (5) permanent-mould casting. In the present Paper the first four processes will be discussed only briefly, and for the purpose of distinguishing them from the process which should properly be termed permanent-mould casting. In the trade, the term "die castings" is often applied, either purposefully or unknowingly, to permanent-mould castings, and this is incorrect and misleading, since the properties and soundness of permanent-mould castings are normally much superior to those of die castings. The five types of processes are defined and discussed briefly below, and comparison is made of the different methods, and the suitable applications of the castings are pointed out.

Die Casting.

A die casting is defined as a finished, or practically finished, casting, made by forcing a liquid metal or alloy into a metallic mould or die. It is

* Private communication, D. H. Meloche, Jan. 4, 1923.

supposed that little or no machining other than drilling for screws, bolts, and the like, and removal of fins by dressing, will be required to put the casting into condition for use. Die castings are sometimes confused with die pressings, which are made by the hot pressing of metals and alloys, and die pressings are often referred to as die-pressed castings and die castings. A die casting is a *finished casting*, in the general meaning of the term, in contradistinction to a rough sand-casting, for which a greater or lesser amount of machining is invariably presupposed. Emphasis should be directed to an essential item in the die-casting process, which sharply distinguishes it from other processes involving metallic moulds, viz., the alloy is forced into the die cavity by pressure; such pressure may be mechanical, as a plunger working in a cylinder, or air pressure.

Die casting, as is the case with other processes involving metallic moulds, is essentially a quantity production process, and but few parts can be considered practical die-casting jobs in lots of less than 1,000. This is necessarily so because of the heavy expense involved in designing and preparing the necessary dies; in small lots, the heavy die expense will be proportionately reflected in the cost of the castings. The cost of any die-casting must normally be less than the cost of producing a sand casting plus the cost of machining to a finished casting equivalent to a die casting. The die-casting process is employed commercially for tin-rich, zinc-rich, lead-rich, and aluminium-rich alloys. Alloys of higher melting points, like the brasses and bronzes, can, of course, actually be die cast, but such alloys have so strong an erosive effect on ordinary die steels that the process is not commercial for these alloys. The life of a die when casting brass is exceedingly short, and at the present time the die-casting process is confined to alloys of relatively low melting points. Die-casting dies for aluminium alloy work are normally made of chrome-vanadium steel.

The die-casting process is especially applicable to the production of small interchangeable parts which do not need to be especially strong and sound, but which are required to be well finished and accurate as to dimensions. The die-casting process has been discussed at length in the technical literature, and attention may be directed to Papers by Pack,[33 34 43] Carman,[44] and Harriman,[45] and to the small book published by The Industrial Press.[36] The die-casting process has been applied very extensively to the production of small parts for automotive construction, household appliances, radio apparatus, adding-machine parts, cash-register parts, and for many other purposes.

Slush Casting.

A slush casting is defined as a practically finished casting made by pouring a liquid metal or alloy into a metallic mould, followed by immediately inverting the mould and thereby pouring out the excess unfrozen alloy in the centre of the mass, thus leaving only the solid shell formed by the contour of the mould. Slush moulds are made usually of brass or bronze, and zinc-rich, and other low-melting point, alloys are employed for casting. The mould is usually mounted upon trunnions, or otherwise arranged so that it may be rapidly inverted. The slush process is adapted for the production of certain types of hollow castings, but it is of no importance for making castings to be used in engineering construction. So far, the process has been confined to the production of vases, dolls, statues, figures, electroliers, and fittings. The process has been described by Rigg and Morse.[18]

Cothias Casting.

A Cothias casting is a finished, or semi-finished, casting made by first pouring a liquid alloy into a metallic mould and then forcing a top half of the mould containing the cores into the alloy whilst liquid, thereby giving internal shape to the casting. In the Cothias process, the lower half of the mould, which conforms in shape to the outside shape of the required casting, is heated, and a measured amount of liquid alloy is poured in; the top half of the mould, conforming to the inside shape of the casting, is then forced into the bottom half in the manner of a stamping press, thus forcing the alloy into the shape of the required casting. The plunger acts as the core. The process is adapted to fairly large castings in fairly low-melting point alloys, *e.g.*, aluminium alloys, where good surface finish and good mechanical properties are required. It is used largely for thin-walled castings of more or less open shape, and it is not applicable to complicated box castings with inside cores. Simple crank-cases, transmission cases, cylinders, and pistons for automotive construction are made in England by this process, in aluminium alloys. The Cothias system is little known in the United States, but is employed to some extent in England and Continental Europe. The process is described in an anonymous article.[31]

Centrifugal Casting.

A centrifugal casting is a finished, or semi-finished, casting made by pouring liquid alloy into a rotatable permanent mould, followed by rapidly rotating the mould so that the alloy is forced to the walls of the mould. In the process centrifugal casting machines are used, and these are extremely simple in design, consisting merely of a mould rotatable at high speed and a spout to supply the alloy. Moulds may be rotated on horizontal, vertical, or inclined axes. Moulds may be made of cast iron or alloy steel, and they may also be made of cast iron lined with clay; they may be run warm, hot, or water-cooled. The warm mould, by which is meant a mould which does not become especially hot and is neither heated by special burners nor water-cooled, was the first development. Water-cooled moulds, as in the De Levaud machines, have been used for making cast-iron pipe, while the hot mould, which permits the casting of quite thin sections, has been developed recently by Cammen. Special high-chromium steel is used for hot moulds.

Practically any cylindrically-shaped body can be made by centrifugal casting, and the process has been applied commercially to the production of pipe, railway-truck wheels, propeller sleeves, paper-mill rolls, tubes, and other parts. While the centrifugal casting of alloys is an old process, it did not assume much importance until about 1914. It has been used for both ferrous and non-ferrous alloys. The process has been described by Cammen.[42 46]

Permanent-Mould Casting.

A permanent-mould casting is defined as a finished, or semi-finished, casting made by pouring a liquid alloy into a metallic mould, the alloy entering the mould and filling the cavity under the force of gravity solely. The process is the counterpart of sand casting, the only difference being in the nature of the mould. The terms "hand-poured die castings" and "gravity-run die castings" have been applied to the products obtained by permanent-mould casting, but these terms are quite unnecessary. By definition, the permanent-mould process can be very readily distinguished from other processes involving the use of metallic moulds, and this process will claim the greater part of attention in the present Paper. Objection has been raised to the use of the term "permanent mould" on the ground that the mould is not really permanent, but requires repairing and upkeep. Of course, nothing is actually permanent, but when several hundred thousand castings can be poured in a mould, either with or without repair, it may be regarded as permanent for all practical purposes.

In the permanent-mould process, when using collapsible steel cores, the liquid alloy is poured into a previously heated and assembled mould, and, after a short time, the cores are removed, the mould parted, and the casting taken out. The mould is then again locked, the core pieces are inserted in the reverse order of removal, and the mould is ready for another pour. Sand cores are also used in the permanent-mould process, and these are normally baked quite hard. For many years the permanent-mould process has been employed for the production of various kinds of cast-iron, brass, and aluminium-alloy castings, but the extensive use of the process is a comparatively recent achievement. At the present time cast-iron, brass, bronze, aluminium-bronze, and light aluminium-alloy castings are made by permanent-mould casting, and the use of this process is rapidly increasing. Permanent-mould casting, like die casting, is a quantity production process, and not many parts should be considered practical for casting in permanent moulds in lots of less than 500 to 1,000. This is so because of the expense of making the moulds, although mould costs in permanent-mould

work are not nearly so high as die-casts in die casting.

The principles of permanent-mould casting as applied to cast iron have been discussed by Custer[8 9 10 11], as applied to non-ferrous alloys by Johnson[23] and an anonymous writer[27 28], and as applied to aluminium-alloy pistons by the present writers.[59]

Comparison of the Processes.

Sand casting, die casting, and permanent-mould casting are competitive processes, while Cothias casting, slush casting, and centrifugal casting occupy rather isolated positions except in the case of the production of special types of castings, when they become competitive to certain of the other processes. This statement is admittedly quite general, and is open to contradiction in numerous instances. In considering the various processes, the producer of castings is interested in knowing the advantages and disadvantages of each, their scope and applications.

Considered broadly, the permanent-mould process may be regarded as occupying a position midway between sand casting and die casting when the light aluminium alloys are considered, and it has a distinct field not covered by either. In comparing permanent-mould casting with sand casting, it is at once apparent that the former is economical only when a fairly large number of castings are to be made, since the cost of preparing the iron mould eliminates the process for consideration when only a few castings are to be poured. For large lots of castings that are suitable to the process, permanent-mould casting is much to be preferred over sand casting, since parts can be made more cheaply, more rapidly, and to closer size- and weight-tolerances. Machining may be eliminated to a considerable extent in permanent-mould castings, thereby effecting considerable savings over sand castings, not only for labour but for metal. One of the most important advantages lies in the fact that permanent moulds can be operated by unskilled labour, although the designing and building of the mould requires highly-skilled mechanics. Skilled labour is required for sand moulding. Referring to aluminium alloys, for large castings and complicated small castings the sand-casting method is generally best. For simple and small castings, and even fairly complicated small castings, which do not need to be particularly strong nor sound, the die-casting method is to be preferred. In the case of reasonably simple and small to moderately large castings, which are to be made in large numbers and which must be strong and sound, the permanent-mould process is advisable.

Compared with sand casting, the process of casting in permanent moulds has limitations as regards size of castings, and whilst large and complicated castings are not normally made commercially in permanent moulds, recent progress indicates that the size and complexity of the casting is limited largely by the ingenuity of the mould designer. There is little question but that many castings are made in the sand foundry which might profitably be made by die casting, and it is also true that some castings are made in permanent moulds which should be made by die casting. On the other hand, some parts are made by die casting which should be produced by permanent-mould casting, or in the sand foundry, and it is only possible to determine the correct method to employ by consideration of the type of castings to be produced. Emphasis should be laid upon the fact that the mechanical properties of permanent-mould-cast alloys are superior to those of die-cast and sand-cast alloys; permanent-mould castings, when properly made, are sound and free from porosity, while die castings are invariably unsound and contain numerous blowholes. Sand castings tend to have greater general unsoundness than permanent-mould castings.

Generally speaking, the permanent mould is cheaper to make than the die employed in die casting, first because the grey cast iron used for the former is more easily machined than the chrome-vanadium steel used for the latter, and second, because, ordinarily, the extreme accuracy specified in the die is not normally required in the mould. Moreover, the cast iron does not require heat treatment, whereas considerable heat treating is necessary in die making. The rate of output by permanent-mould casting is more rapid than by sand casting, but less than by die casting, and the accuracy is greater than in sand but less than in dies. The speed of production in permanent-mould casting is, of course, dependent upon the size and type of the casting being made, the composition of the alloy used, and the type of mould employed, referring more especially to whether automatic or hand-operated moulds are used. The rate of production is also affected markedly by the coring and as to whether sand or collapsible steel cores are used. Rate of output can be increased for small and simple castings by gating several together in a permanent mould and casting from one runner, as in a sand mould. The die-casting process has the advantage of great speed and accuracy, and it is much more economical than sand casting or permanent-mould casting for certain types of parts. However, where definite physical properties are demanded and where castings are to be heat treated, *e.g.*, aluminium-alloy castings, the permanent-mould process is to be preferred. Die castings cannot be heat treated to advantage, first because they are unsound and "blow-holey," and therefore unreliable as to strength, and second, because heating for annealing or quenching causes evolution of gas from the internal holes and consequent blistering. Larger castings can be made in permanent moulds than in dies, and definite and reliable properties can be secured. From the point of view of engineering construction, permanent-mould castings are much to be preferred over die castings or sand castings, since they possess better physical properties for the same alloy and are more free from blowholes and porosity.

In the matter of slush casting, this process occupies a distinct field of usefulness for the production of hollow and thin-walled castings in low-melting point alloys, but its scope of application is scant. The Cothias process does not offer any particular advantage over permanent-mould casting except that the use of mechanical pressure tends to give finer grained and stronger castings. At the same time, the process is limited as to the types of castings that can be made by it, and also by the circumstance that, so far, it is applicable only to fairly low-melting point alloys. It has not been used for brass and cast iron. Centrifugal castings is a useful process for the production of cylindrically-shaped castings, and owing to the pressure exerted by the centrifugal force, it yields fine-grained and strong castings. Moreover, any alloy can be cast centrifugally. The process cannot, however, have wide application in the foundry industry because of inherent limitations in the type of casting that can be made by it.

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(To be continued.)

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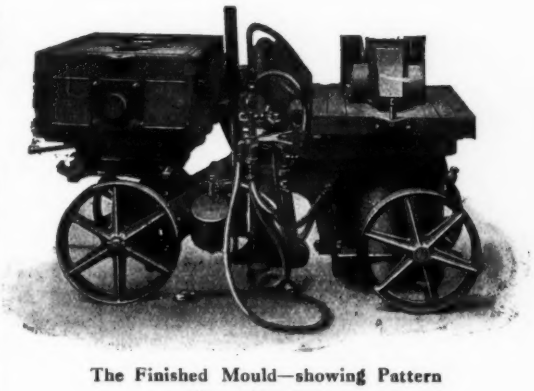

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Obituary.

MR. W. BLOOMER, machinery merchant, of Accrington, died recently, aged 70.

MR. THOMAS FAIRCLOUGH, traffic manager of the Vulcan Foundry Company, Limited, Warrington, died recently.

MR. HENRY HEATH COCHRANE, whose death is announced, was formerly a director of Cochrane & Company, Limited, severing his connection with that firm some years ago.

MR. P. T. J. ESTLER, of Estler Bros., engineers, aluminium and brass founders, South Moldon Road, Victoria Docks, London, E., died recently in his 52nd year. He was a member of the executive committee of the London District Association of Engineering Employers.

MR. SAMUEL SPENCER, chairman of J. E. and S. Spencer, Limited, tube merchants, of Dowgate Hill, Cannon Street, London, E.C.4, and a director of John Spencer, Limited, tube manufacturers, of Wednesbury, died on May 16 in his 86th year. He was formerly connected for over 25 years with the Horseley Bridge and Engineering Company, Limited, of Tipton.

MR. EDWARD CROWE, of Saltburn, who was well known in Tees-side industrial circles, died last week. The deceased, who was 63 years of age, was born in Middlesbrough. He entered the engineering profession and became associated with the firm of Davey Bros., Sheffield. Twenty years ago he accepted an appointment as consulting engineer for the South Durham Steel and Iron Company and the Cargo Fleet Iron Company, but failing health compelled him to relinquish his connection with the latter firm. Mr. Crowe was an ex-president of the Cleveland Institute of Engineers.

Gazette.

THE GRAFTON ENGINEERING COMPANY, LIMITED, are being wound up voluntarily. Mr. A. Walker has been appointed liquidator.

THE GRAY ELECTRICAL COMPANY, LIMITED, are being wound up voluntarily, with Mr. W. A. J. Osborne, Balfour House, Finsbury Pavement, E.C., as liquidator.

MR. W. A. PATTERSON, trading as J. Hornsby & Company, 23, North Street, Middlesbrough, engineers' merchant, is paying a first and final dividend of 4s. 10½d. in the £.

THE PARTNERSHIP between Messrs. C. W. Dalman and J. H. Dalman, ironfounders, Chunk Foundry, River Street, Birmingham, under the style of J. C. Dalman & Sons, was dissolved on May 16.

MESSRS. J. CLAYTON and R. CHADWICK, electrical and mechanical engineers, 67, Wortley Lane, Leeds, trading under the style of Clayton & Chadwick, have dissolved partnership, but R. Chadwick will continue the business.

Contracts Open.

Bucharest, June 14.—About 55 tons of galvanised-iron wire, for the Roumanian State Railways. The Department of Overseas Trade.

Dundee, June 9.—Stores, for the Tramways Committee. Mr. W. T. Young, general manager, Tramway Office, Dundee.

Glasgow, June 7.—Stores, for the trustees of the Clyde Navigation, from July 1, 1924, for three, six or twelve months. The Superintendent of Stores, 1, Graving Dock, Govan.

Plymouth, June 12.—Cast-iron pipes, for the Corporation. Mr. E. G. Okell, borough electrical engineer, Prince Rock Electricity Works, Plymouth. (Fee, £1, returnable.)

South Molton, June 10.—Iron water pipe and fittings, etc., for the R.D.C. Mr. W. S. Gardner, surveyor, Chittlehampton.

Stockton-on-Tees, June 7.—Stores, for the Joint Tramways Committee of the Stockton-on-Tees and Thornaby Corporations. The Manager, Bridge Road, Stockton-on-Tees.

Walton, June 10.—Thirteen steel pipes and specials required for the 60-in. section main at their Walton pumping station, for the Metropolitan Water Board. The Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1.

Wellington, N.Z., July 29.—Eight galvanised steel transmission line towers, complete with cross-arms, ground members and accessories, for the Public Works Department. The Department of Overseas Trade (Room 50), 35, Old Queen Street, London, S.W.1.

Belgium, June 18.—Bare phosphor-bronze cable, for the Ministry of Railways, Marine, Posts and Telegraphs. The Department of Overseas Trade (Room 52), 35, Old Queen Street, London, S.W.1.

Maryport, June 7.—Installation of a suction gas engine and/or crude oil engine and a treble ram pump capable of raising 600 gallons per minute at the Cockermouth pumping station, for the Maryport U.D.C. The Water Engineer, Town Hall, Maryport.

Stoke-on-Trent, June 11.—(a) Chemical degasser, 150,000 lbs. of feed water per hour; (b) weigh tanks and weighbridge for 30,000 lbs. of water; (c) steelwork extension to pump-house crane gantry, steel girders and platform for vertical pump motor, expanded metal screen, chequer plates, etc.; (d) two electric battery trucks for ash handling; (e) universal woodworking machine, for the Town Council. Borough Electrical Engineer, St. Peter's Chambers, Stoke-on-Trent. (Fee £2.)

Toronto, June 10.—Air compressor, for the City of Toronto Department of Works, the Department of Overseas Trade.

Trade Talk.

THE BLAENAVON COMPANY, LIMITED, have put their two furnaces out of blast.

JAMES JENKINS & SON, iron, steel and ore merchants, 124, St. Vincent Street, Glasgow, have removed to 45, Renfield Street, Glasgow.

PEASE & PARTNERS, LIMITED, are about to issue 796,143 shares of £1 each at par to existing shareholders in proportion to their holdings.

RICHARD THOMAS & COMPANY, LIMITED, have removed their offices from 47/51, King William Street, London, E.C.4, to Bush House, Aldwych, W.C.2.

DOWDING & DICKINSON, machine tool merchants, of Windsor House, Victoria Street, London, S.W.1, have engaged the services of Mr. W. M. Pudge, who has for the last eleven years been with George Kent, Limited, Luton, where he held the position of works engineer. Mr. Pudge had previously been for many years with D. Napier & Sons, of Acton, and W. M. Still, of Hatton Garden.

HOLLINGS & GUEST, LIMITED, Thimble Mill Lane, Birmingham, are experiencing an increasing demand for their hydraulic presses and pumps from the Continent, several French, Belgian and Swiss firms having recently placed orders with them for hydraulic machinery. There are also a large number of presses and pumps going through the works for use at home, or in the Colonies.

SIR FREDERICK MILLS, who has undertaken the chairmanship of the annual dinner of the Royal Metal Trades Pension Society, is making a personal appeal for the support of the trade. The Society has made itself responsible for the payment of pensions of £6,500 per annum, and has an assured net income of £3,600 only. It is therefore dependent for its continued usefulness upon the adventitious aid afforded by the subscription list for this dinner.

AN INCREASE of 2½ per cent. is to take place in the wages of men employed under the sliding scale agreement governed by the Scottish Manufactured Iron Trade Conciliation and Arbitration Board. The increase, which takes effect on Monday, June 2, will remain in force for two months. Sir John M. MacLeod has intimated to the joint secretaries of the Board that he has examined the employers' books for March and April, and certifies that the average net selling price brought out is £12 7s. 11.93d.

FOLLOWING UPON AN assurance that the National Light Castings Ironfounders' Federation will meet early this month to consider the recent demand for increases in wages made by a joint committee of the nine Trade Unions connected with the light metal trades, the men have been instructed by their officials to continue at work until further notice. For time workers over 21 years of age an increase of 15s. per week is demanded, while an equivalent percentage of weekly earnings is asked in the case of piece-workers.

THE ANNUAL MEETING of the Society of Chemical Industry will be held at Liverpool this year, from July 9 to 12. The morning of the opening day will be occupied by the presidential address on "A Neglected Chapter in Organic Chemistry: The Fats." In the afternoon there will be a visit to the White Star Liner "Cedric," and in the evening a reception and dance in the Town Hall. On Thursday, July 10, the Messel Memorial Lecture will be delivered by the Rt. Hon. Viscount Leverhulme. There will be a visit to the works of Joseph Crossfield & Sons, Limited, Warrington, and in the evening the annual dinner in the Midland Adelphi Hotel. On Friday, July 11, there will be a business session in the Physics Lecture Theatre of the University, a luncheon at the Midland Adelphi Hotel, and a visit to the works of the United Alkali Company, Limited, and in the evening a dinner at Port Sunlight. The following day will be occupied by a visit to Lake Vyrnwy, and an inspection of the Liverpool Corporation Waterworks.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH. — Influenced by the near approach of Whitsun, business in the Cleveland iron market has relapsed into the quiet conditions which were marked previous to the recent improvement in Continental exchange rates, with buying at the moment strictly confined to hand-to-mouth dealings for immediate requirements of consumers. The fall in the franc and the effects of deflation in Germany are alike inimical to active export business. While there would seem to be no immediate chance of the effective competition of Continental pig-iron in this country, the currency position abroad is now undoubtedly protective to French and Belgian interests. On the whole, however, as stated last week, a genuine revival of export trade with the Continent can only follow upon a general European financial resettlement. Having regard to all the circumstances, values are very steady, but in this week's market the price was down to 91s., while there is a disposition to make further concession. No. 1 was 95s.; No. 4 foundry 89s. 6d., and No. 4 forge 89s. per ton.

The Tees-side market for hematite at the moment is weaker relatively than foundry iron, owing in the main to the flatness of the export position. East Coast mixed numbers were this week quoted at 98s., but this was only a nominal figure, some makers accepting 97s. 6d. per ton. The No. 1 quality was 1s. per ton more. Values in the north-west area are unchanged, Bessemer mixed numbers being quoted at 107s. 6d. per ton at Glasgow, 112s. 6d. at Sheffield, and 117s. 6d. at Birmingham. Low-phosphorus iron is in fair request by steel makers in the Sheffield district.

MANCHESTER.—Demand for foundry iron in the local market continues limited in volume, most consumers being well booked forward for deliveries over the half-year, without much prospect at present of adding to their commitments. Sellers of Derbyshire pig-iron in this district usually quote now on a basis of 94s. at the furnaces, or, roughly, at 101s. 6d. per ton, delivered in the Manchester area; but there are some who refuse to sell under 95s., and, on the other hand, there are occasional sales at 93s. 6d. The latter seems to be the lowest price which can be relied upon, although there have been rumours of less.

THE MIDLANDS.—The slightly easier tendency reported at Birmingham last week is maintained, Derbyshire, Northants and Staffs. foundry iron having been reduced in price to the extent of about 2s. per ton, and further reductions are likely to follow unless business assumes a brighter aspect, which at the moment does not appear imminent. The current figures are as follow:—Derbyshire No. 3 foundry, 93s. 6d. to 95s.; Staffordshire No. 3 foundry, 94s. to 95s.; Northants No. 3 foundry, 91s. 6d.

SCOTLAND.—Conditions in the northern pig-iron market continue dull, with buyers apparently becoming scarcer as the days pass, and prices a shade easier, the quotation for No. 3 foundry being 99s. at the furnaces. There is keen competition for any orders which come into the market, and even for the smallest quantity business only follows after some bargaining.

Finished Iron.

There is a quietly steady trade in marked bars, but in all other branches conditions are desperately dull. Orders are given out very sparingly, and it is impossible to keep the works going full time, or anything like it. Foreign competition is not more troublesome than it was. The difficulty seems to be that there is no life whatever in the trade. Under such circumstances it is remarkable that quotations remain so steady. For the best quality of crown bars one or two makers of special repute still quote £13 as a basis, and it is not a question of whether their quotation is firm or not. They will not book orders for less. There is no improvement in demand for nut and bolt iron, but the price has not been altered. It is still held that a lower price would not in the least stimulate business because of the pressure of steel competition. Marked bars remain firm at £15.

Steel.

The markets for all descriptions of steel material remain in a state of uncertainty, with business on the whole quiet. In semis, the demand for acid billets is fairly good, in consequence of the heavy production for railway purposes of acid open-hearth steel. With regard to basic billets, some makers are declining to quote the market price of £8 15s. any longer for soft qualities, holding that this figure means a loss. Anything up to £9 10s. is being quoted by these firms. At last week's market, tinplates were done on the basis of the minimum schedule price of 23s. 6d. basis, I.C. f.o.b. works port, and it is reported that the outlook is brighter than for some weeks past. No improvement in ferro-manganese can be reported, and only small parcels are changing hands either on home or export account. Business in America is beginning to show signs of recovery, and, at any rate, several consumers will have to come into the market very shortly. The price is unchanged.

Scrap.

There is little improvement in demand visible in the various centres of the old metal trade, but in the Lancashire foundry scrap market prices are quietly steady at 87s. 6d. to 92s. 6d. for good cast scrap, according to quality. The higher price is asked for broken textile machinery iron, but it is doubtful whether it is being paid. The demand all round is quiet, simply because the ironfounders here are not doing much work, and not because there is any grumbling about the prices. In Scotland machinery cast-iron scrap is still inactive, with practically no change in the price, *i.e.*, 97s. 6d. per ton, although more inquiries from foundries were in evidence recently. Ordinary cast-iron scrap in handy pieces is 3s. 6d. to 5s. per ton less, but the demand is also rather poor. Old cast-iron railway chairs were also inquired for, at approximately 97s. 6d. to 98s. 6d. per ton. Light cast-iron scrap is 79s. to 80s. per ton, and with fire-bars mixed with it, about 2s. 6d. per ton less.

Metals.

Copper.—Some slight improvement may be noted in the position of this metal since last reported, the weakness then prevailing having been succeeded by a firmer tendency in standard values. In the States, copper producers have shown more readiness to sell, and after some firmness, in sympathy with the standard market, values have fallen away, with little support forthcoming at the lower levels, 13.70 cents being about the nominal price now asked. Business in Germany and France is of very small dimensions, but it is encouraging to be able to write that consumption in this country shows no sign of falling off. Current quotations:—*Cash*: Thursday, £61 10s.; Friday, £61 10s.; Monday, £61 12s. 6d.; Tuesday, £61 15s.; Wednesday, £61 17s. 6d. *Three Months*: Thursday, £62 7s. 6d.; Friday, £62 7s. 6d.; Monday, £62 10s.; Tuesday, £62 15s.; Wednesday, £62 17s. 6d.

Tin.—Speculative influences in the tin market having for the time being subsided, values during the past week have shown symptoms of partial recovery, with some indications of a continuance of more favourable conditions. The Eastern sales under the Bandoeng agreement, which of late have shown considerable decline, may be expected to develop on a scale nearer the limit permitted if the present improvement continues until prices are on a more favourable basis. So far as the consumptive demand in Great Britain is concerned, the further decline in prices has had the effect of checking rather than encouraging fresh buying. Current quotations:—*Cash*: Thursday, £211; Friday, £208 5s.; Monday, £212 5s.; Tuesday £209 12s. 6d.; Wednesday, £211 15s. *Three Months*: Thursday, £209 5s.; Friday, £206 10s.; Monday, £210 5s.; Tuesday, £208 17s. 6d.; Wednesday, £211 5s.

Spelter.—The market for this metal shows some improvement, possibly in sympathy with better all-round conditions, with a corresponding recovery in values. The small parity between New York and London is undoubtedly influencing the action of dealers, who feel that American producers would not be unwilling to consider a bid at near the value on this side. Current quotations:—*Ordinary*: Thursday, £31 2s. 6d.; Friday, £31 2s. 6d.; Monday, £30 17s. 6d.; Tuesday, £31; Wednesday, £31 5s.

Lead.—Values have also improved in the market for soft foreign pig, prompt supplies being reported scarce. The decline in consumption, natural after great activity, will probably come sooner or later, and it may be that the tendency now present in America in this connection may be a foreshadowing of what is to happen here in the near future. Current quotations:—*Soft foreign (prompt)*: Thursday, £30 7s. 6d.; Friday, £31 5s.; Monday, £30 17s. 6d.; Tuesday, £30 15s.; Wednesday, £31.